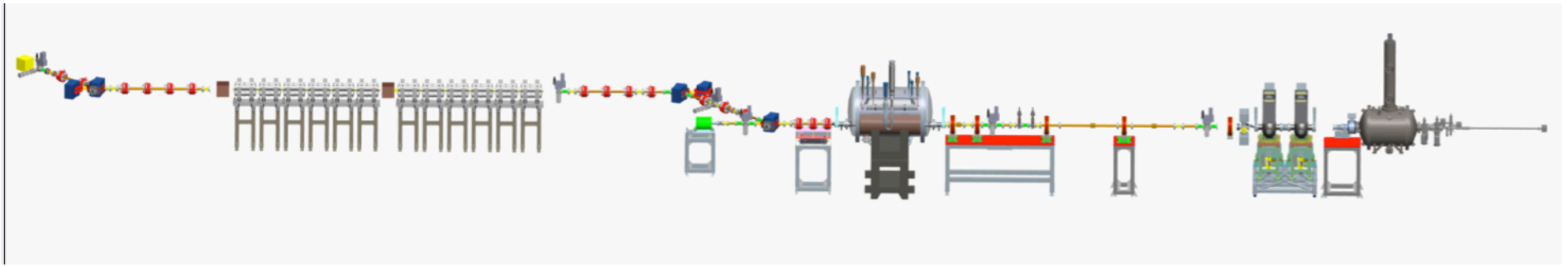
Coherent electron Cooling Proof of Principles Experiment: Q&A

Vladimir N. Litvinenko - PI
Igor Pinayev – Project physicist
Joseph Tuozzolo – Project Engineer

for CeC team



Question

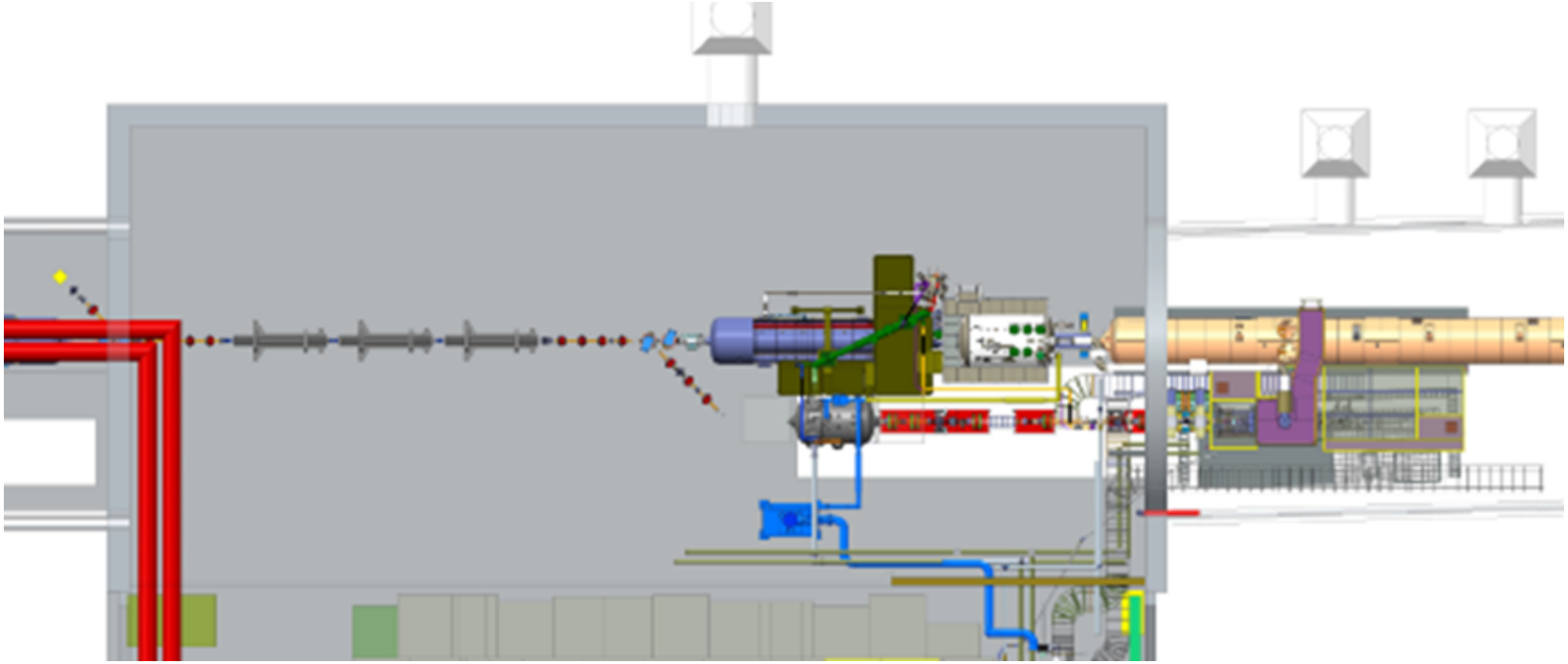
1. Is there any back-up plan for any schedule slippage in the CeC system ?

Comments form Joe Tuozzolo:

At this time the two last major pieces of equipment are in hand and in the tunnel or are being prepped to be moved to the tunnel (the 5 cell cavity and the undulators). All other components (stands and some custom adapter beam line vacuum tubes) are in hand or on order with short lead times.

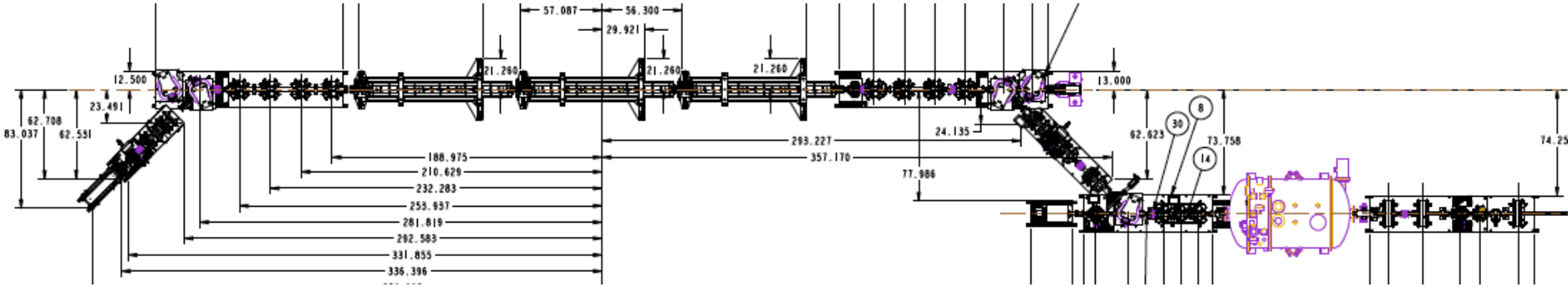
The major concern is the cryogenic equipment ordered a year ago and due in the end of September. Installation will take 6 to 8 weeks. Further delay will mean OT (overtime) installation during December. We did this two years ago for the 56 MHz RHIC cavity with much less area preparation and completed the installation by delaying the RHIC run. Pushing the cryogenic installation to 12 hour days, it should be completed in 4 weeks.

Phase 3: Full Energy Beam Line Installation - 2015



- Install 704 MHz Systems and supporting cryogenic system
- Install Wiggler Magnets
- Install RHIC beam line components: dipoles, quads, correctors, vacuum
- Install beam diagnostics Modify and install RHIC DX-DO chamber for FEL light diagnostics
- Move CeC beam dump line to final location

Final configuration



Schedule

Four month is left for the CeC installation

Delivery of 704 MHz linac to BNL	V	30-Jul-15
Assembling and tuning helical wigglers	V 1/3	15-Aug-15
Install 704 MHz in RHIC tunnel	x	15-Nov-15
Install helical wigglers in RHIC tunnel	x	01-Dec-15
CW laser is commissioned	x	01-Dec-15
Beam diagnostics is intalled		15-Dec-15
Optical diagnostics is installed		15-Dec-15
Complete CeC beam-line	**X**	**15-Dec-15**

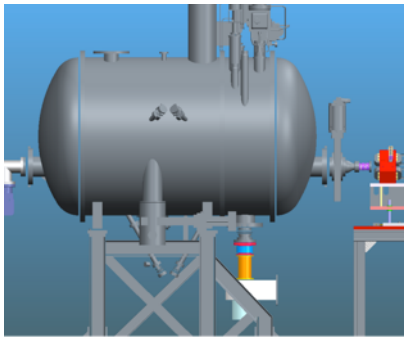
Legend: x – milestone, X – major milestone

Phase 3 - 704 MHz 5 Cell Cavity From Niowave

Delivery from Niowave – July 15, 2015

Coax in house being installed

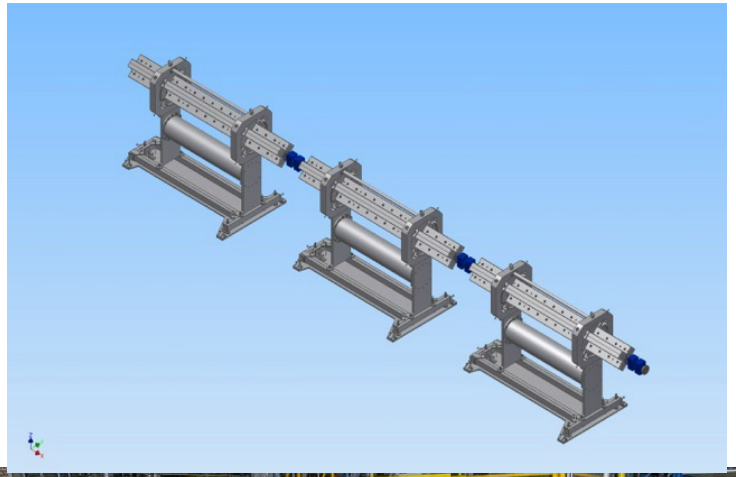
FPC welding at AES is finished



704 MHz 5 Cell SRF linac
(cryomodule)
assembled at NioWave Inc

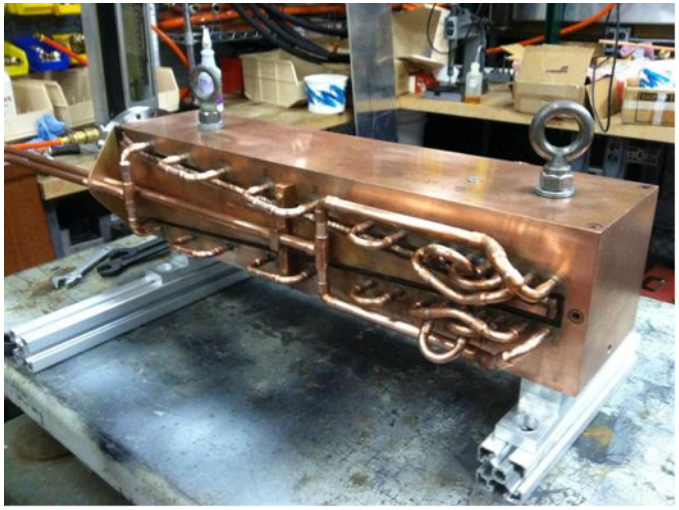
Cliff Brutus welcomes it at IP2

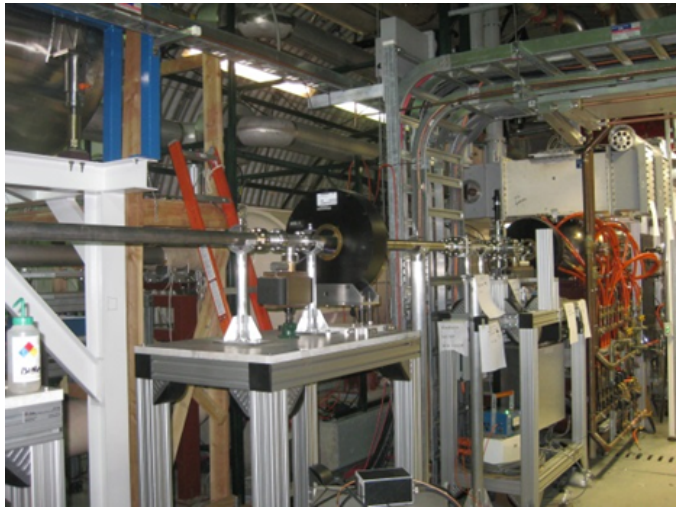
Three Helical PM Wigglers at BNL from BINP (Novosibirsk). BINP team visited in July 2015

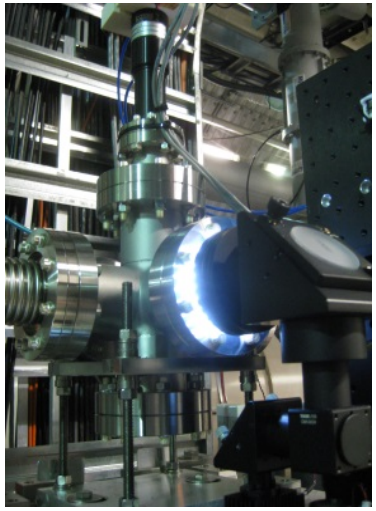


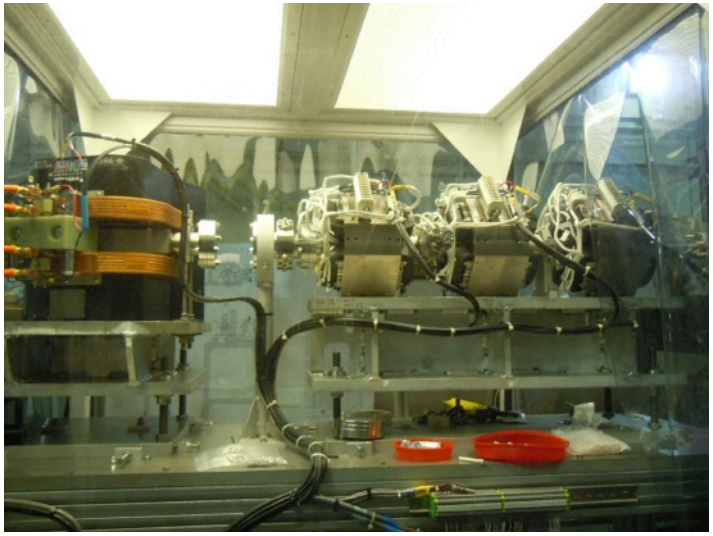
Left to right: Domenick Milidantry (SMD), Pavel Vobly (BINP), Ray Ceruti (SMD), Igor Ilin, Victor and Sergey Shadrin, Vitalii Zuev (all BINP) and Igor Pinayev (C-AD) near the first assembled helical wiggler

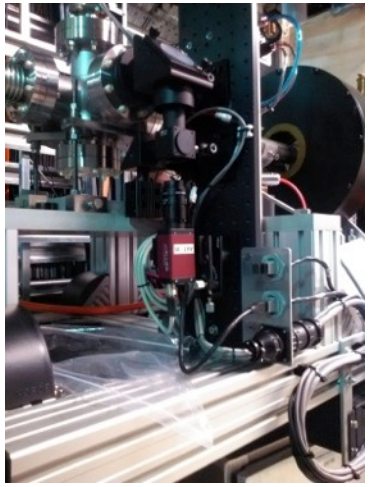
Beamline Components





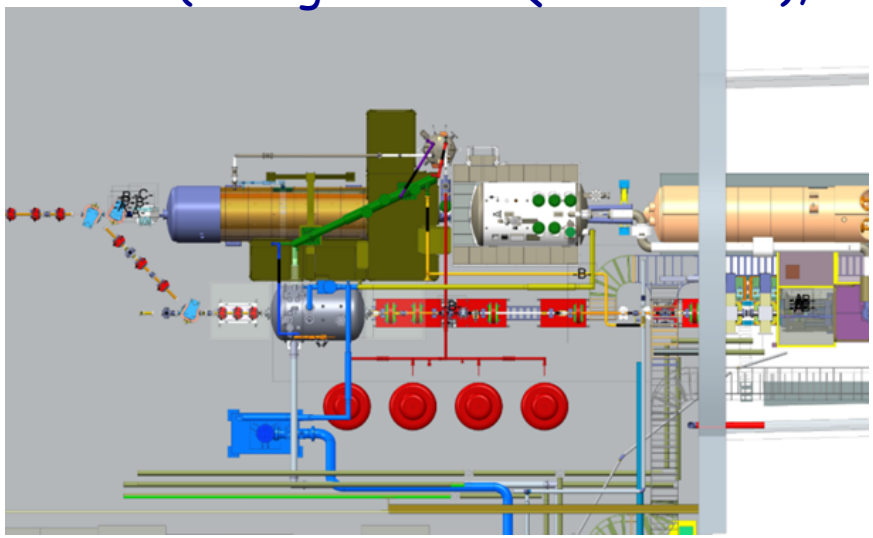


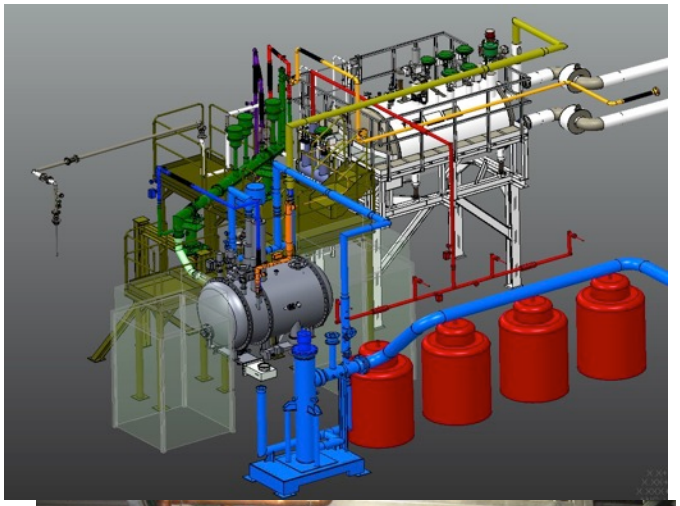




704 MHz SRF linac 2 K Cryogenics

- Integration with LEReC supply and return requirements complete
- All components ordered: VJP (green monster), heater return (blue), cooldown return (lime green to QHS heater), heater skid.





Q&A

1. Is there any back-up plan for any schedule slippage in the CeC system ?

A: I would not call it a plan, but the list of our options:

(a) Since RHIC Run 16 is shorter than usual, there is a possibility of requesting (or natural occurring) of later start of RHIC run. Then deadline of Dec. 15, 2015 can move to ~ mid-February 2015.

(b) If schedule slipped further, then we could using RHIC maintenance days to finish the installation of the equipment (albeit it is very slow!)

(c) We could request using APEX time for the maintenance – it will double the time available costing a grief to AP folks at C-AD

(d) We could either request extending RHIC run (which is very costly) or – as the final stretch – attempt to use batch filling during 2016 shut-down. This will be in clear conflict with installation of the LEReC equipment.

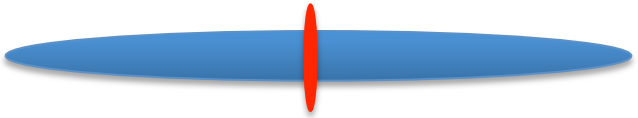
(e) Finally, we could try to commission the system and demonstrate CeC during Run 17 – while possible in principle, this is clearly the very last resort. In this case, we will be in competition with LEReC during RHIC 2016 2016 shut-down.

Question

2. Are there any particular measurements (and associated simulations) that are required to verify the POP.

Detecting CeC action

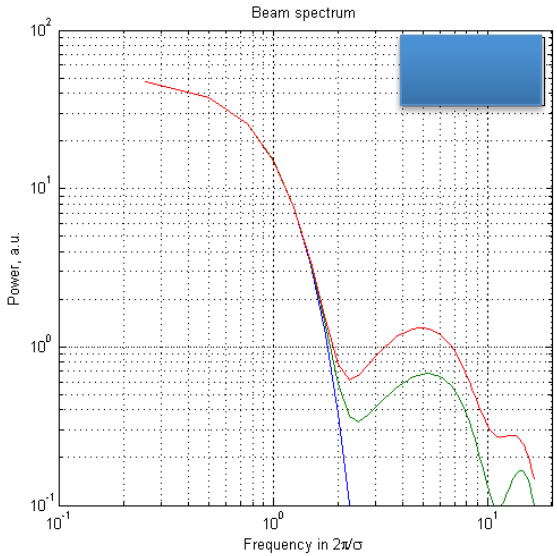
Electron bunch – 10 psec



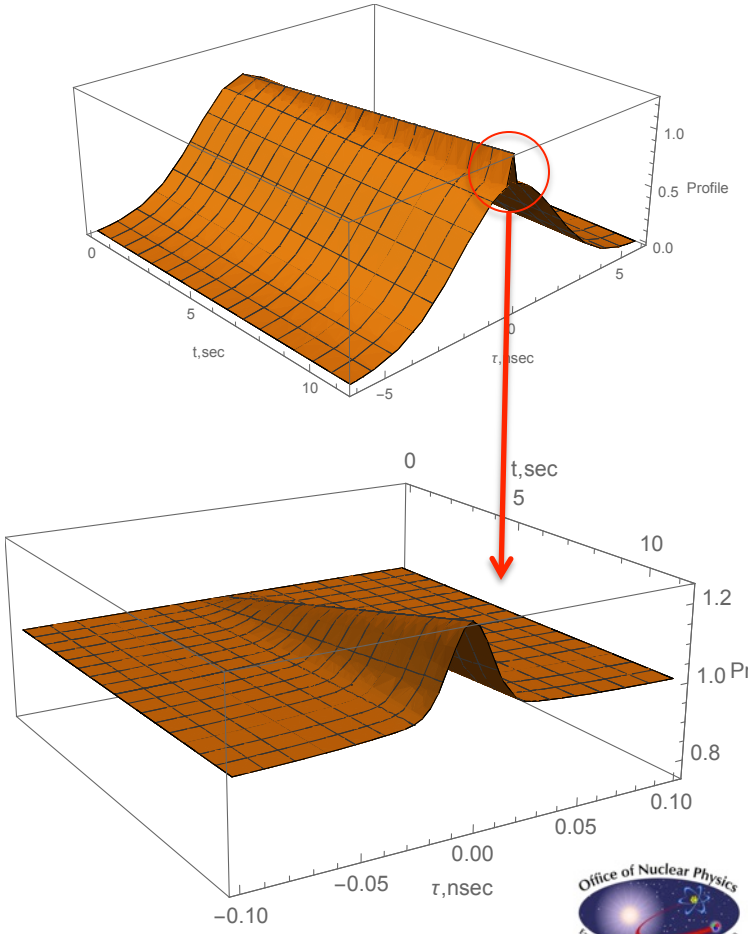
Ion bunch – 2 nsec

Simulated Au ion beam profile evolution with CeC PoP parameters

r.m.s. length of the cooled part 80-120 ps. The cooling effects can 2 GHz (or more) bandwidth using spectrum analyzer or digital scope



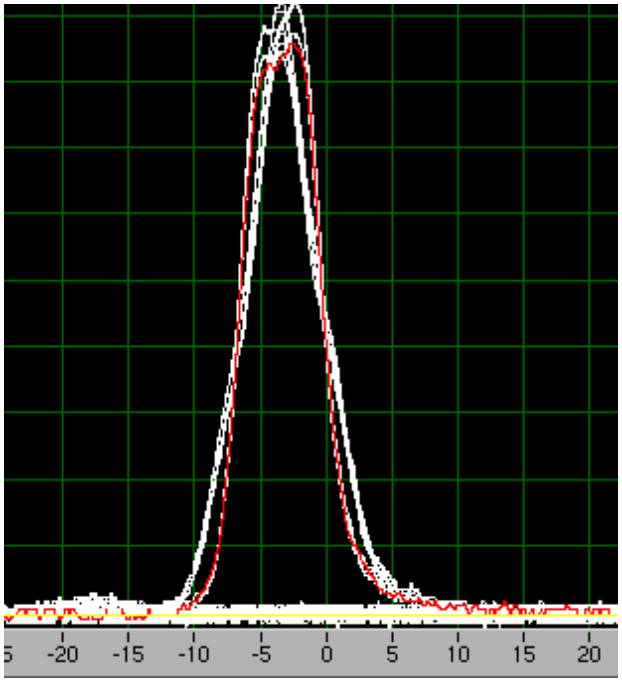
Well above noise floor

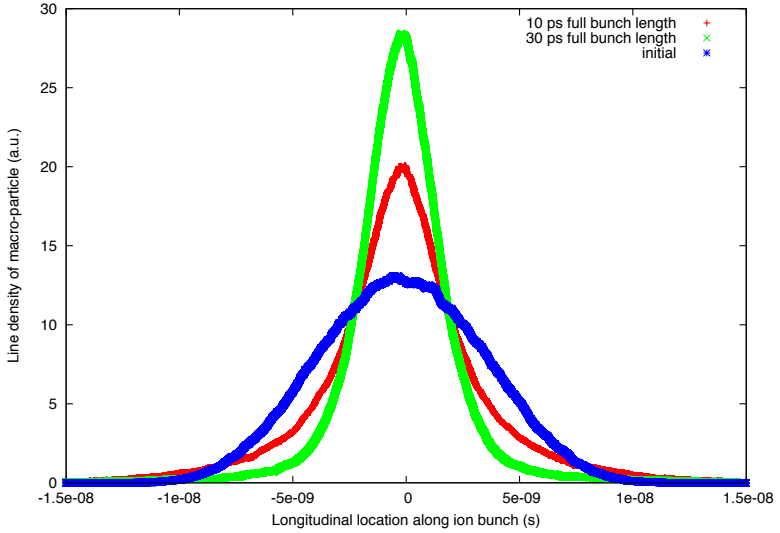


Q&A

2. Are there any particular measurements (and associated simulations) that are required to verify the (CeC) POP.

A: Yes, we should measure the variation of the longitudinal profile of the ion bunch using RHIC's wall current monitor and to observe increase of density in the bunches center and compare it with simulations



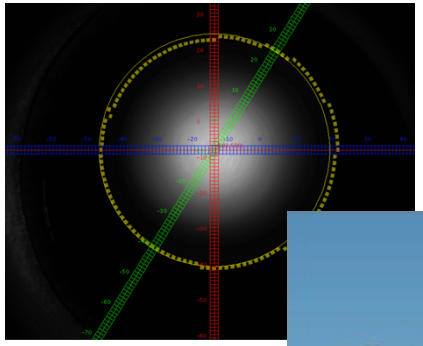


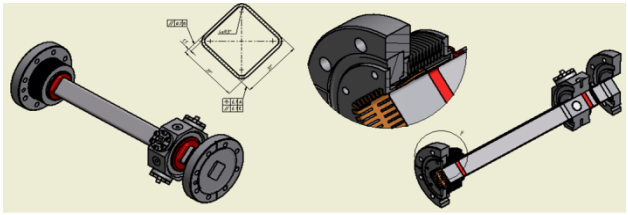
Question

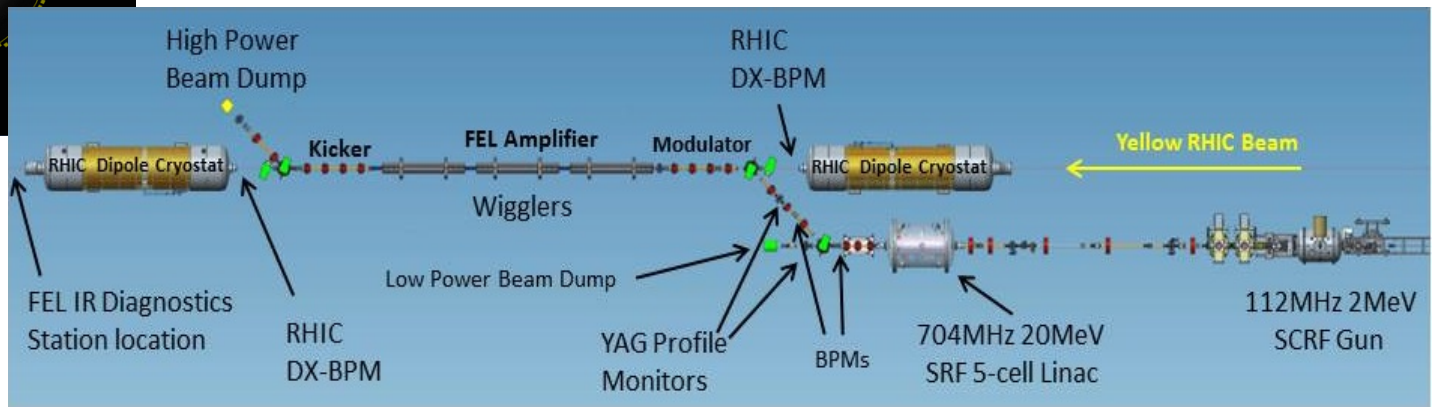
3. Is there a need to pre-qualify the electron beam ? if so how ?

Electron Beam and FEL Parameters for CeC PoP experiment

Electron Beam	
RMS Energy Spread	$\leq 1\times10^{-3}$
Normalized Emittance	≤ 5 μm·rad
Peak Current	60-100 A







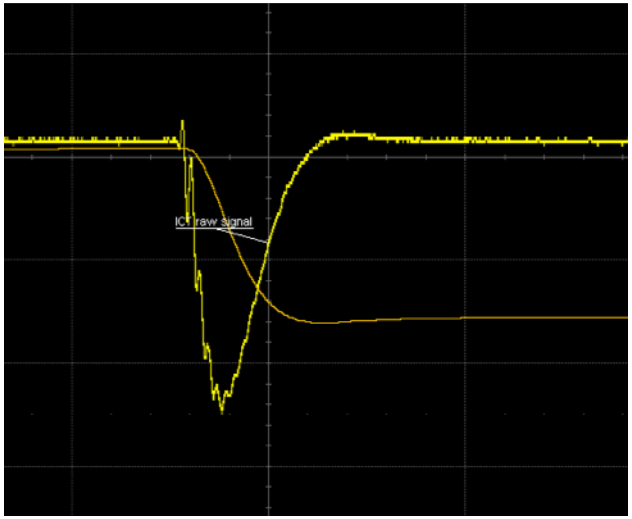
First beam from 112 MHz gun – June 2015

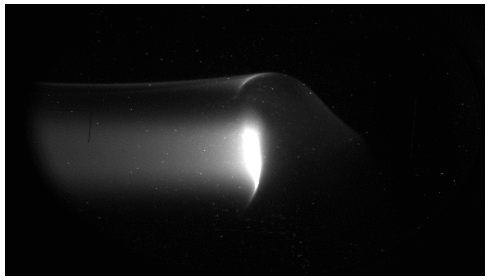
1.6-1.7 MeV (kinetic energy) in CW mode

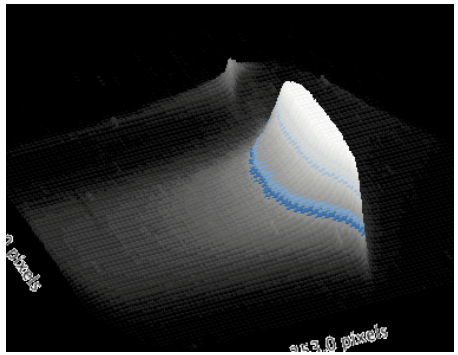
Laser generated CW e-Beam with 3 nC @ 5 kHz

2 MeV in pulse mode

25 MV/m at photocathode







Milestones reported to DoE NP Q3 FY15

Demonstrating operation of 112 MHz SRF gun with 3 nC charge per bunch, 1.6 to 1.7 MeV kinetic energy in CW mode and above 2 MeV in pulsed mode.

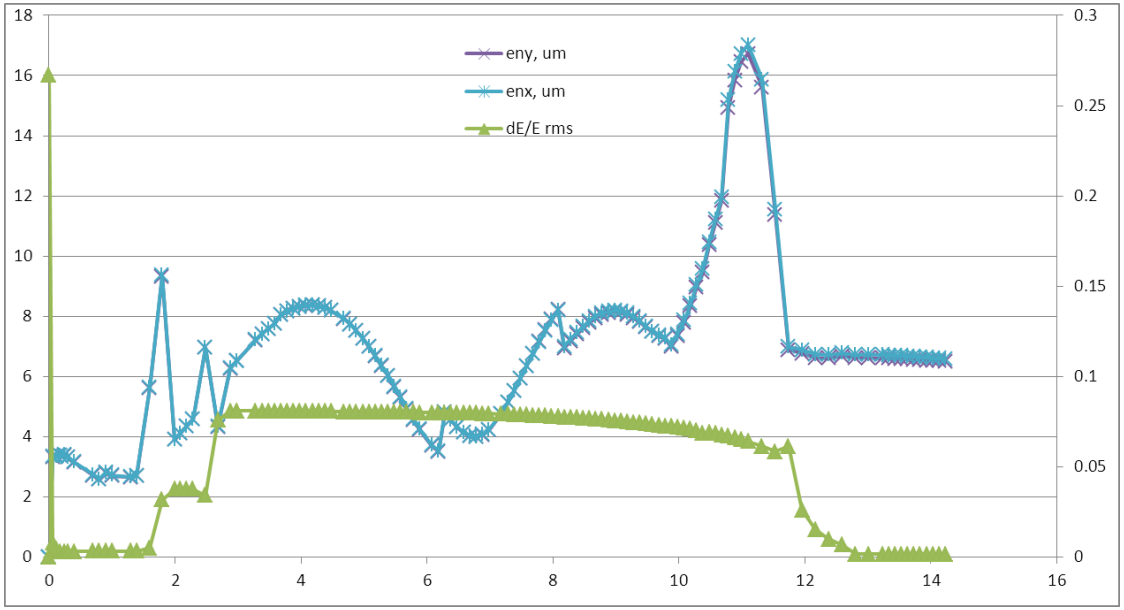
Production of high QE photocathodes for 112 MHz SRF gun.

Receiving helical wiggler system for CeC PoP FEL amplifier

Completion of the 704 MHz SRF linac cryo-module at NioWave Inc.

Completing the low energy transport beam line and its control system.

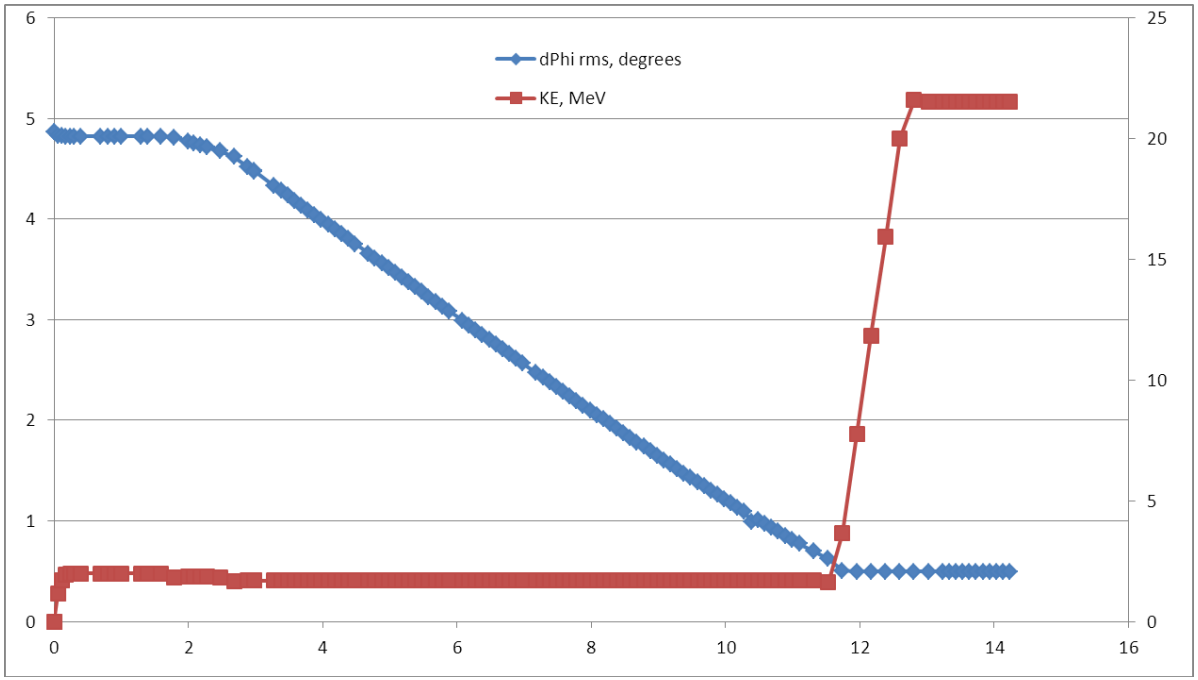
Expected Electron Beam Parameters



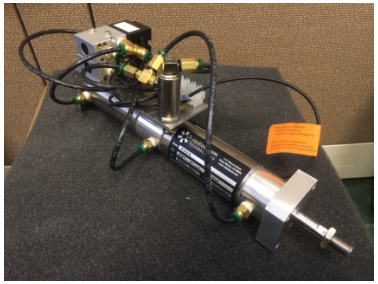
Calculations are done for 2 nC bunch
Core charge is 1.3 nC
Emittance is 8.6 μm, core emittance is 3.3 μm

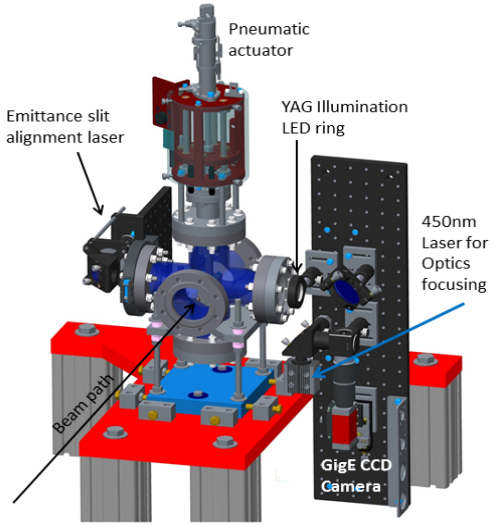
Relative energy spread is 2×10^{-3}, relative energy spread in the core is 3×10^{-4}

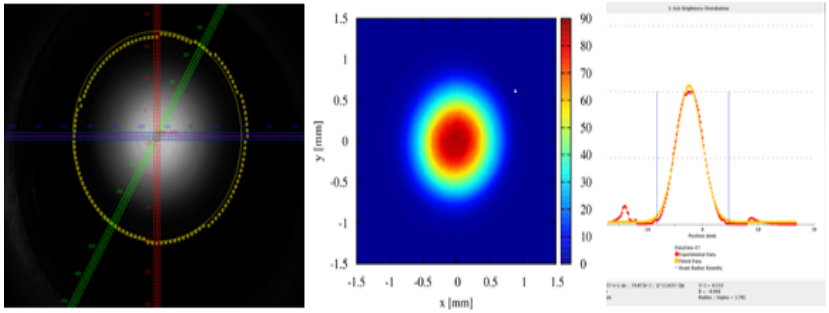
Courtesy D. Kayran



CeC PoP diagnostics







Q&A

3. Is there a need to pre-qualify the electron beam ? if so how ?

Not as we know, but we will measure and optimize e-beam parameters for proper simulations of CeC process

(a) Ion beam parameters are sufficient and are well characterized – we just needed to re-establish RHIC ramp to 40 GeV/u

(b) We plan to characterize the main beam e-beam parameters: energy, charge, emittance, energy spread, peak current using our beam diagnostics:

ICT, Pepper-pot, spectrometer in combination with 704 MHz linac, screens.

Back-up slides

Schedule for RHIC run 16

(dates are tentative and will be adjusted to RHIC Run 16)

Commissioning	Milestones		
SRF cavities cold	x	15-Feb-16	Has to be sinchroniozed with RHIC crun
Complete cavity conditioning	**X**	**15-Mar-16**	
Generating fist beam	**X**	**01-Apr-16**	Assuming that SRF gun is working with photocathode pack
Measuring beam parameters	X	15-Apr-16	
Propagate beam to the beam dump	x	01-May-16	
Test co-propagation with ion beam	**X**	**15-May-16**	
Demonstrate FEL amplification	**X**	**01-Jun-16**	
First cooling attempt	**X**	**01-Jul-16**	Dedicated 5 days of running, dates have to be adjusted to the end of the RHIC run

This is very aggressive schedule aiming not only for commissioning of the CeC PoP system but also for detecting local cooling. Can be affected if p-A operation is scheduled for RHIC Run 16…

Schedule - demonstration

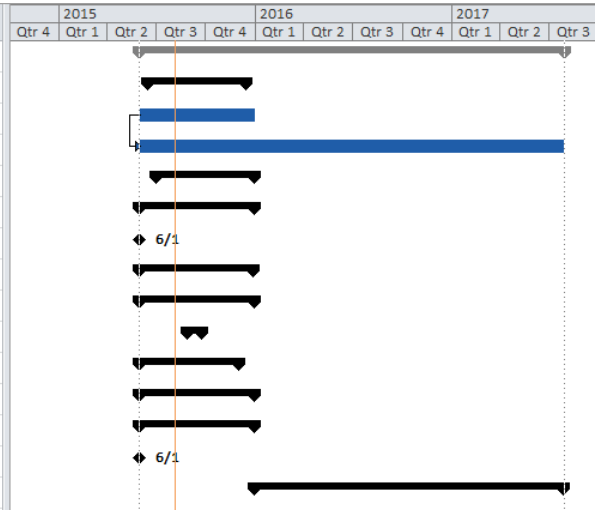
(dates are tentative and will be adjusted to RHIC Run 17)

Making necessary up-grades/ improvements	01-Jul-16	31-Dec-16	Improving and updating diagnostics, optical system as well as installing buncher for ACeC test
SRF cavities cold	x	15-Feb-17	Has to be synchronized with RHIC run
Complete cavity conditioning	**X**	**01-Mar-17**	
Recreating operational conditions	**X**	**21-Mar-17**	
Start CeC PoP experiments (using APEX shifts)	**X**	**07-Apr-17**	
Demonstrate microbunching amplification (ACeC)	x	30-May-17	if time allows
Demonstrate CeC PoP cooling	**X**	**30-Jun-17**	
CeC cooling experiments end	**X**	**30-Jun-17**	Dates have to be adjusted to the end of the RHIC run

This schedule assumes that CeC systems are installed and commissioned with RHIC ion beam during RHIC run 16.

Resource Loaded Schedule

WBS	Task Name	% Complete	Work	Cost	Start	Finish
1.	Coherent Electron Cooling (CeC) Experiment	10%	41,938 hrs	$8,511,691	6/1/2015	7/28/2017
1.1	Milestones	0%	0 hrs	$0	6/15/2015	12/15/2015
1.2	Project Management	0%	2,260 hrs	$408,068	6/1/2015	12/31/2015
1.3	Physics Support	0%	21,824 hrs	$3,173,125	6/1/2015	7/28/2017
1.4	SCRF Electron Gun	0%	0 hrs	$0	7/1/2015	12/30/2015
1.5	SCRF Linac Cavity	8%	264 hrs	$590,322	6/1/2015	12/31/2015
1.6	Buncher Cavity	100%	0 hrs	$0	6/1/2015	6/1/2015
1.7	Magnets + Power Supplies	10%	4,506 hrs	$745,317	6/1/2015	12/28/2015
1.8	Instrumentation Gassner	28%	1,216 hrs	$551,478	6/1/2015	12/31/2015
1.9	Beam Dump	0%	56 hrs	$9,369	8/28/2015	9/23/2015
1.10	Vacuum	0%	1,058 hrs	$519,500	6/1/2015	11/30/2015
1.11	Cryogenics	0%	2,076 hrs	$326,730	6/1/2015	12/31/2015
1.12	Controls Jamikowski	0%	934 hrs	$224,058	6/1/2015	12/31/2015
1.13	Civil Construction	100%	0 hrs	$0	6/1/2015	6/1/2015
1.14	Commissioning	0%	7,744 hrs	$1,963,724	12/31/2015	7/26/2017



Resource Name	Work	Cost
Building Trades-Riggers	42 hrs	$6,466
Building Trades-Carpenters	**84 hrs**	**$12,932**
Building Trades-Electricians	**472 hrs**	**$72,664**
Central Shops	**498 hrs**	**$76,667**
Designer	500 hrs	$77,355
IT Professional	880 hrs	$150,841
Admin	880 hrs	$155,619
purchases < $25K	178,414	$276,542
Grad Student	**10,560 hrs**	**$316,800**
Engineer	**2,189 hrs**	**$435,545**
Technician	**6,771 hrs**	**$1,047,541**
purchases > $25k	893,000	$1,062,670
Scientist	**19,008 hrs**	**$4,820,049**

Project Name	CeC Experiment
Total FTEs	**23.8**
Unburdened Material Cost (k$)	**$1,071**

Steps

1. Install the entire CeC beam-line and diagnostics, except the wiggler section
2. Install a NEG-coated pipe instead of the wiggler section
3. Propagate full power 20 MeV e-beam to the beam dump, can be used for testing bunched e-cooling
4. Install wiggler section in parallel to the IP2 and commission it with single shot (low power) beam and low power beam dump
5. At the end of the RHIC run – move the wiggler section in (3-4 days) and run CeC tests

Initial configuration